Claims

We claim:

1. A device for forming an array of magnetic particles, the device comprising:
a substrate comprising a plurality of magnetic regions, wherein the magnetic regions produce a plurality of localized magnetic fields when magnetized, and wherein the localized magnetic fields are sufficient to trap a magnetic particle with a trapping energy at least five times greater than the thermal energy of the particle at room temperature.

2. The device of claim 0, wherein the localized magnetic fields are sufficient to trap a magnetic particle with a trapping energy at least an order of magnitude greater than the thermal energy of the particle at room temperature.

3. The device of claim 0, wherein the localized magnetic fields are sufficient to trap a magnetic particle with a trapping energy at least three times greater than the thermal energy of the particle at room temperature.

4. The device of any of claims 0, 2, or 3, wherein the thermal energy of the particle is approximately 0.025 eV.

5. The device of any of claims 0, 2, or 3, wherein the localized magnetic fields exist substantially in a volume between adjacent magnetic regions.

6. The device of any of claims 0, 2, or 3, wherein each of the localized magnetic fields corresponds to a different single magnetic region and exists substantially in a volume between opposite poles of that magnetic region.

7. The device of any of claims 0 to 4, wherein the magnetic regions project above the surface of the substrate.

8. The device of claim 7 wherein the magnetic regions have walls that are substantially perpendicular to the substrate.

9. The device of claim 7, wherein the magnetic regions comprise a layer of magnetic material and a layer of nonmagnetic material, wherein the layer of nonmagnetic material is located between the substrate and the layer of magnetic material.

10. The device of claim 0, wherein the magnetic material regions are arranged in a pattern of mutually perpendicular rows and columns.

11. The device of claim 0, wherein the magnetic regions are arranged in an array of subarrays configuration.

12. The device of claim 0, wherein the magnetic regions are substantially uniform in shape.

13. The device of claim 0, wherein the magnetic regions are substantially rectangular in shape.

14. The device of claim 0, wherein the magnetic regions have a circular cross-section.

15. The device of claim 0, wherein the magnetic regions are substantially uniform in size.

16. The device of claim 0, wherein the number of magnetic regions is at least 1000 per centimeter squared.

17. The device of claim 0, wherein the number of magnetic regions is at least 10,000 per centimeter squared.

18. The device of claim 0, wherein the number of magnetic regions is at least 100,000 per centimeter squared.

19. The device of claim 0, wherein the number of magnetic regions is at least 250,000 per centimeter squared.

20. The device of claim 0, wherein the number of magnetic regions is at least 1,000,000 per centimeter squared.

21. The device of claim 0, wherein adjacent magnetic regions are separated by a gap approximately equal in size to the size of a magnetic particle.

22. The device of claim 21, wherein the magnetic particle has a greatest dimension selected from the group consisting of: 30 nm, 100 nm, 300 nm, 500 nm, 1 μm, 3 μm, 5 μm, and 10 μm.

23. The device of claim 22 wherein the magnetic particle is substantially spherical, and the greatest dimension of the particle is the diameter of the particle.

24. The device of claim 0, wherein adjacent magnetic regions are separated by a gap having a greatest dimension approximately equal in size to the greatest dimension of a magnetic particle.

25. The device of claim 24, wherein the gap has a greatest dimension approximately equal in size to the greatest dimension of a magnetic particle having a greatest dimension selected from the group consisting of: 30 nm, 100 nm, 300 nm, 500 nm, 1 μm, 3 μm, 5 μm, and 10 μm.

26. The device of claim 25, wherein the magnetic particle is substantially spherical, and the greatest dimension of the particle is the diameter of the particle.

27. The device of claim 21, wherein the gap has a minimum length of approximately 1 micron.

28. The device of claim 21, wherein the gap has a minimum length of approximately 3 microns.

29. The device of claim 21, wherein the gap has a minimum length of approximately 5 microns.

30. The device of claim 0, wherein the magnetic regions comprise a magnetic material.

31. The device of claim 30, wherein the magnetic material is a ferromagnetic material.

32. The device of claim 0, wherein the substrate comprises a nonmagnetic material

33. The device of claim 0, wherein at least a portion of the device comprises a biocompatible material.

34. The device of claim 0, wherein at least the surface of the substrate and the magnetic regions comprises a biocompatible material.

35. The device of claim 32, wherein the magnetic regions are surrounded by nonmagnetic material.

36. The device of claim 32, wherein the substrate comprises silicon.

37. The device of claim 0, wherein the magnetic regions comprise cobalt.

38. The device of claim 0, wherein the magnetic regions are formed using photolithography.

39. The device of claim 0, wherein the magnetic particles are magnetic beads.

40. The device of claim 0, wherein the magnetic particles are paramagnetic particles.

41. The device of claim 0, wherein the magnetic particles are superparamagnetic particles.

42. The device of claim 0, further comprising a flux circulator.

43. The device of claim 0, further comprising a plurality of photodetectors.

44. The device of claim 0, further comprising a microfluidic assembly.

45. The device of claim 0, further comprising a plurality of magnetic particles.

46. The device of claim 45, wherein the magnetic particles are substantially uniform in size and shape and are magnetic beads.

47. The device of claim 45, wherein the magnetic particles are substantially uniform in size and shape and are paramagnetic beads.

48. The device of claim 45, wherein the magnetic particles are substantially uniform in size and shape and are superparamagnetic beads.

49. The device of claim 45, wherein the magnetic particles are trapped by the localized magnetic fields.

50. The device of claim 45, wherein each of a plurality of the magnetic particles comprises a detectable moiety.

51. The device of claim 50, wherein the detectable moiety comprises a fluorescent or luminescent molecule.

52. The device of claim 50, wherein the detectable moiety comprises a nucleic acid.

53. The device of claim 52, wherein the nucleic acid comprises a hybridization tag.

54. The device of claim 45, wherein each of a plurality of the magnetic particles has a probe attached thereto.

55. The device of claim 54, wherein the probe comprises a binding ligand.

56. The device of claim 54, wherein the probe comprises a nucleic acid molecule.

57. The device of claim 54, wherein the probe comprises a protein.

58. The device of claim 0, further comprising a magnet for magnetizing and demagnetizing the magnetic regions.

59. A device for forming an array of magnetic particles, the device comprising:

a substrate comprising a plurality of magnetic regions, wherein the localized magnetic regions produce a plurality of localized magnetic fields, and wherein the magnetic regions project above the surface of the substrate.

60. The device of claim 0, further comprising a plurality of magnetic particles.

61. The device of claim 0, wherein the magnetic regions are substantially uniform in size and shape.

62. The device of claim 0, wherein the magnetic regions are arranged in a pattern of mutually perpendicular rows and columns.

63. A device for forming an array of magnetic particles, the device comprising:
a nonmagnetic substrate; and
a plurality of magnetic regions located on the substrate, wherein a localized magnetic field exists between adjacent magnetic material regions when magnetized.

64. The device of claim 0, further comprising a plurality of magnetic particles.

65. The device of claim 0, wherein the magnetic regions are substantially uniform in size and shape.

66. The device of claim 0, wherein the magnetic regions are arranged in a pattern of mutually perpendicular rows and columns.

67. The device of claim 0, wherein the magnetic regions project above the surface of the substrate.

68. A device for forming an array of magnetic particles, the device comprising:
a substrate comprising a plurality of magnetic regions, wherein the magnetic regions produce a plurality of localized magnetic fields when magnetized, and wherein the localized magnetic fields generate forces sufficient to trap a magnetic particle with a trapping energy at least five times greater than the thermal energy of the particle at room temperature.

69. A randomly ordered array of magnetic particles.

70. The array of claim 0, wherein the magnetic particles are trapped by localized magnetic fields.

71. The array of claim 0 or claim 70, wherein the magnetic particles are beads.

72. The array of claim 71, wherein each of a plurality of the magnetic particles comprises a probe.

73. The array of claim 71, wherein the beads are encoded.

74. A method of forming an array of magnetic particles comprising:
contacting the device of any of claims 0, 0, or 0 with a plurality of magnetic particles.

75. The method of claim 0, wherein the plurality of magnetic particles comprises at least two populations of magnetic particles, wherein the populations are distinguishable.

76. The method of claim 0, wherein the step of contacting comprises dispensing the magnetic particles in a fluid medium.

77. The method of claim 0, further comprising the steps of:
removing a majority of the magnetic particles from the device; and
reusing the device in a subsequent analytical process.

78. An array formed according to the method of claim 0.

79. A method of forming an array of magnetic particles comprising steps of:
contacting magnetic particles with a device comprising magnetic regions that produce localized magnetic fields, whereby a plurality of the magnetic particles are trapped by the localized magnetic fields.

80. The method of claim 0, wherein the step of contacting comprises dispensing the magnetic particles in a fluid medium.

81. The method of claim 0, wherein the magnetic particles comprise at least two populations of magnetic particles, wherein the populations are distinguishable.

82. The method of claim 0, further comprising the steps of:
removing a majority of the magnetic particles from the device; and
reusing the device in a subsequent analytical process.

83. An array of magnetic particles formed according to the method of claim 0.

84. The array of claim 0, wherein each of a plurality of the magnetic particles comprises a probe.

85. The array of claim 0, wherein the magnetic particles comprise at least two populations of magnetic particles, wherein the populations are distinguishable.

86. A method of analyzing a sample comprising:
contacting the sample with magnetic particles, wherein each of a plurality of the magnetic particles comprises a probe;
forming an array of the magnetic particles; and
determining whether a probe interacts with a target in the sample.

87. The method of claim 0, wherein the determining step comprises performing an assay selected from the group consisting of: a genotyping assay, a hybridization assay, an SBE assay, an OLA assay, an ASPE assay, an allelic PCR assay, an exonuclease assay, and an invasive cleavage assay.

88. The method of claim 87, wherein the plurality of magnetic particles comprises at least two populations of magnetic particles, with each population comprising a unique probe selected from a set of universal hybridization tags.

89. The method of claim 88, wherein the sample contains targets, and wherein the targets in the sample contain sequences complementary to the universal hybridization tags, and wherein generation of the targets involves reformatting

any arbitrary nucleic acid sequence to be detected to a unique sequence chosen from the set of universal tags.

90. The method of claim 0, wherein the determining step comprises performing an enzyme-linked immunosorbent (ELISA) assay.

91. The method of claim 0, wherein the contacting step occurs before the forming step.

92. The method of claim 0, wherein the forming step occurs before the contacting step.

93. The method of claim 0, wherein the plurality of magnetic particles comprises at least two populations of magnetic particles, wherein each of the populations of magnetic particles comprises a different probe.

94. The method of claim 0, wherein the plurality of magnetic particles comprises at least two populations of magnetic particles, wherein the populations are distinguishable.

95. The method of claim 94, wherein each population of beads is labeled with a detectable moiety, wherein the detectable moieties differ in amount or in chemical structure between different populations of magnetic particles.

96. The method of claim 95, wherein the detectable moiety is a fluorescent or luminescent molecule or a hybridization tag.

97. The method of claim 0, wherein the step of determining comprises:
determining whether a probe binds to a target.

98. The method of claim 0, wherein a target interacts with a probe, and wherein the determining step comprises:
determining the identity of the probe.

99. The method of claim 0, wherein a target interacts with a probe, and wherein the determining step comprises:
determining the identity of the target.

100. The method of any of claims 0, 97, 98, or 99, wherein the probe and the target comprise nucleic acid molecules.

101. The method of any of claims 0, 97, 98, or 99, wherein the determining step comprises detection using a confocal scanner or a charge coupled device.

102. A method of analyzing a sample comprising:
contacting the sample with magnetic particles, wherein each of a plurality of the magnetic particles comprises a probe;
forming an array of the magnetic particles; and
performing an assay selected from the group consisting of: a genotyping assay, a hybridization assay, an SBE assay, an OLA assay, an ASPE assay, an allelic PCR assay, an exonuclease assay, and an invasive cleavage assay, and an enzyme-linked immunosorbent (ELISA) assay.

103. The method of claim 102, wherein the contacting step occurs before the forming step.

104. The method of claim 102, wherein the forming step occurs before the contacting step.

105. The method of claim 102, wherein the magnetic particles comprise at least two populations of magnetic particles, wherein the populations are distinguishable.

106. The method of claim 102, wherein the magnetic particles comprise at least two populations of magnetic particles, wherein each of the populations comprises a probe.

107. The method of claim 102, wherein the plurality of magnetic particles comprises at least two populations of magnetic particles, with each population comprising a unique probe selected from a set of universal hybridization tags.

108. The method of claim 102, wherein the sample contains targets, and wherein the targets in the sample contain sequences complementary to the universal hybridization tags, and wherein generation of the targets involves reformatting any arbitrary nucleic acid sequence to be detected to a unique sequence chosen from the set of universal tags.

109. A method of analyzing a sample comprising:
contacting the sample with magnetic particles, wherein each of a plurality of the magnetic particles comprises a probe;
forming an array of the magnetic particles; and
performing an enzyme-linked immunosorbent (ELISA) assay.

110. A method of fabricating a device comprising steps of:
providing a substrate;
producing magnetic regions in or on the substrate, wherein the magnetic regions produce a plurality of magnetic fields when magnetized, and wherein the localized magnetic fields are sufficient to trap a magnetic particle with a trapping energy at least five times greater than the thermal energy of the particle at room temperature.

111. A method of fabricating a device comprising:
providing a substrate;
producing magnetic regions in or on the substrate, wherein the magnetic regions produce a plurality of localized magnetic fields, and wherein the magnetic regions project above the surface of the substrate.

112. The method of claim 111, wherein the magnetic regions comprise a magnetic material, and wherein the magnetic regions are fabricated using photolithography.